European Review for Medical and Pharmacological Sciences 2022; 26: 6328-6339

Diagnostic accuracy of ultrasonography for detecting gastric tube placement: an updated meta-analysis

J. PENG[1,2], M. TANG[4], L.-L. LIU[3], W.-T. CHEN[4], Q.-H. YE[4]

[1]Zhejiang Chinese Medical University, Hangzhou, Zhejiang, China
[2]Department of Critical Care Medicine and Urology Surgery, Taizhou Integrated Chinese and Western Medicine Hospital, Taizhou, Zhejiang, China
[3]Emergency Department of Yinzhou No. 2 Hospital, Ningbo, Zhejiang, China
[4]Department of Emergency, The First People's Hospital of Linhai, Taizhou, Zhejiang, China

J. Peng, M. Tang and L.-L. Liu contributed equally to this work

Abstract. – OBJECTIVE: This study aimed at reviewing the diagnostic accuracy of ultrasonography for detecting correct nasogastric tube placement compared with X-ray imaging as the reference standard.

MATERIALS AND METHODS: This was a systematic review and meta-analysis of observational studies published between 1961 and 2022. We included studies that compared the diagnostic accuracy of ultrasound detection for nasogastric tube placement with that of X-ray imaging in adult patients who were undergoing nasogastric tube placement for any reason. We searched for published studies in the following electronic databases: Cochrane Library, PubMed, EMBASE, and Web of Science. The risk of bias was assessed using a standard procedure according to the Quality Assessment of Diagnostic Accuracy Studies-2 criteria. The results were analyzed using RevMan or Meta-Disc software to determine the adequacy and conclusiveness of the available evidence.

RESULTS: Fourteen studies met our inclusion criteria. Overall, 1,812 patients were included in these studies. The results included a pooled sensitivity of 0.96 (95% confidence interval [CI] 0.94-0.97), specificity of 0.91 (95% CI 0.85-0.96), positive likelihood ratio of 5.08 (95% CI 1.49-17.39), and negative likelihood ratio of 0.08 (95% CI 0.06-0.10). This was confirmed through a summary receiver operating characteristic curve, which showed that the area under the curve was 0.96.

CONCLUSIONS: We found evidence about validity of ultrasound as an efficient method for verifying nasogastric tube placement, although there is insufficient evidence to suggest that it can be used as a diagnostic tool for incorrect gastric tube placement.

Key Words:
Ultrasound, Nasogastric tube, X-rays, Enteral nutrition.

Introduction

Gastric tubes are commonly used to administer medications to people who cannot swallow or deliver nutrition directly into the gastrointestinal tract[1]. A gastric tube is placed by inserting it through the nose (nasogastric tube, NGT) or mouth (orogastric tube or orogastric tube) and following the esophagus into the stomach[2]. Insertion of an NGT is a complex procedure that requires the skill and expertise of the practitioner, as misplacement of the NGT in the airway can lead to serious complications, including pneumonia, pneumothorax, pulmonary edema, oropharyngeal perforation, pulmonary hemorrhage, and death[3,4]. Between 2005 and 2010, 21 deaths and 79 injuries related to feeding *via* misplaced NGT were reported in the UK[5].

The recommended methods to confirm proper tube placement are X-ray observation and aspiration of gastric fluid[6]. X-ray images are the gold standard for confirming the position of the gastric tube. One study[7] evaluated the position of more than 2,000 NG tubes using X-ray images as the gold standard. Malpositioning was present in 1.3%-2.4% of the cases. Of these cases, 26% resulted in complications, such as pneumonia and pneumothorax, whereas two patients died due to misplacement. In prehospital situations, a combination of suction and auscultation is often used because of the absence of X-ray

Corresponding Authors: Weiting Chen, MD; e-mail: chenweitingwl@sina.com
Qiuhe Ye, MD; e-mail: yeqiuhezj@sina.com

images[8,9]. This method involves the injection of 20 mL of air into an NG tube to auscultate gurgling sounds in the epigastrium. However, evidence from a systematic review[10,11] concluded that this approach is not desirable because of the risk of false-negative results and failure to identify misplaced NG tubes.

As technology and equipment continue to advance, point-of-care ultrasonography is becoming increasingly common in clinical settings. Scholars[12] have shown that ultrasonography provides a good estimate of diagnostic accuracy for confirming appropriate placement. Thus, ultrasonography may provide a promising alternative to X-ray imaging for confirming intubation, especially when X-ray facilities are not available or are difficult to use.

Materials and Methods

We performed a systematic review and meta-analysis of observational studies using the methods outlined in the Cochrane Handbook for Reviews of Diagnostic Test Accuracy and in accordance with the Preferred Reporting Items for a Systematic Review and Meta-analysis of Diagnostic Test Accuracy Studies (PRISMA-DTA)[13]. This systematic review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO registration No. CRD42022331236).

Criteria for Considering Studies for this Review

Types of studies

Studies on the diagnostic accuracy of nasogastric and orogastric tube placement confirmation by ultrasound visualization compared with the gold standard of X-ray visualization were included. We included controlled diagnostic test accuracy studies (prospective cohort study, cross-sectional study, and case-control study) of ultrasound and X-ray visualization.

We excluded uncontrolled reports (case series and case reports), in addition to studies on ultrasound guided NGT placement and verification or gastrostomy and enteric tube placement. Studies in which the diagnostic accuracy of ultrasonography (e.g., specificity or sensitivity) was not recorded or could not be calculated were also excluded. Studies where X-ray visualization was not the reference standard and if the true-positive (TP), false-negative (FN), false-positive (FP), and true-negative (TN) values could not be extracted were also excluded.

Participants

The study included both adults and children who required gastric tube placement in any care setting for any reason.

Index tests

This included ultrasound confirmation of gastric tube placement in the neck and abdomen. Visualization of the tube usually involves the neck, abdomen, or both. A tube seen directly in the esophagus or stomach was interpreted as being correctly placed. We included all studies regardless of where ultrasonography was performed or the person performing the exam or whether the ultrasound technique was enhanced by injecting saline and air into the tube.

Target condition

This refers to the appropriate placement of a gastric tube for any reason.

Reference standards

The reference standard was X-ray images of either the chest or abdomen.

Search Methods for Identification of Studies

Electronic searches

With the consultation and advice of librarians, different search strategies have been developed based on the search features of each database. We systematically searched the English databases of Cochrane Library, PubMed, EMBASE, and Web of Science from their inception to May 2022. The following search terms were used in English: intubation, nasogastric tube, feeding tube, fine bore tube, gastrointestinal, enteral nutrition, ultrasound, ultrasonography, and sonography. Animal studies were excluded.

Searching other resources

We screened the list of references in relevant trials to identify any further potential papers worth reviewing.

Data Collection and Analysis

Selection of Studies

Two authors (Wang and Tang or Lin) independently reviewed the titles and abstracts of the articles identified in the search process. The full texts of potentially relevant studies that met our inclusion criteria were retrieved and independently assessed for relevance by Wang and Tang. Disagreements regarding eligibility were resolved by a third person (Lin).

Data Extraction and Management

Two reviewers (Wang and Tang) independently extracted data on study characteristics, patient demographics, participant demographics, sample size, test methods, methodological quality, sensitivity, and specificity. Both reviewers extracted data to construct a 2 × 2 contingency table including TP = correct gastric tube placement and correct visualization by ultrasonography; FP = incorrect gastric tube placement but not visualized by ultrasonography; FN = correct gastric tube placement but not visualized by ultrasonography; TN = incorrect gastric tube placement and correct visualization by ultrasonography.

Assessment of Methodological Quality

The Quality Assessment of Diagnostic Accuracy Studies-2 tool was used to assess the risk of bias in the included studies[14]. The characteristics of the included studies were recorded. **Appendix 1** describes the assessed qualities in detail. For each item in the quality assessment form, we included a description of how the study was addressed in the tool with a judgment of low, high, or unclear, and an overall risk of bias was given for each domain. In addition, for the overall concern of the applicability of the domain of review questions, we added the judgments of low, high, and unclear. An assessment of methodological quality was presented to show all judgments made for all the included studies. Two review authors (Wang and Tang or Lin) independently assessed the methodological quality, and a final decision was made by agreement.

Statistical Analysis and Data Synthesis

Data synthesis was performed using the methods recommended in the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy. For all the included studies, forest plots were used to demonstrate the number of TP, TN, FP, and FN, as well as the sensitivity and specificity, and their 95% confidence intervals (CI). Summary receiver operating characteristic (SROC) plots were used to demonstrate the results of the individual studies in the ROC space, and each study was plotted as a single sensitivity-specificity point.

For the meta-analysis, a bivariate random-effects model was used to determine summary estimates of sensitivity and specificity with 95% confidence and prediction regions if quantitative data synthesis was acceptable[15]. The clinical utility of ultrasonography using likelihood ratios was assessed to enable the calculation of post-test probability using Fagan's nomogram[16]. Two-tailed p-values < 0.05 were considered significant. All analyses were performed using Review Manager 5.3 or Meta-DiSc software[17].

Investigations of Heterogeneity

Heterogeneity was investigated by visually examining the forest plots of sensitivities and specificities and the result of I^2 statistics for each index test. Exploration of potential sources of heterogeneity through subgroup analysis and meta-regression (including country, sample size, study design, patient age, and area of visualization, e.g., the neck, abdomen, or both, and whether tests conducted before the index test with saline or air injection) were planned.

Sensitivity Analysis

A "leave-one-out" procedure was performed to assess the effect of each study on the meta-analysis. This means that a single study from the meta-analysis was removed each time to reflect the effect of the individual dataset for the pooled results.

Assessment of Reporting Bias

We did not explore reporting bias due to a lack of suitable statistical methods.

Results of the Search

We identified 20,676 studies through electronic searches of PubMed (8,620 records), Web of Science (9,625 records), Cochrane (1,662 records), and Embase (769 records). No additional records were identified from other sources.

After excluding duplicates, 14,016 studies remained. We, then, excluded 13,987 studies by reading the titles and abstracts. We retrieved 34 studies for further assessment. Of the 34 studies, 15 were excluded for reasons listed in Figure 1. The flow of references during the selection process is illustrated in Figure 1. A summary of the included studies is shown in Table I[8-10,18-29].

Methodological Quality of the Included Studies

The methodological quality of the included 15 studies is shown in Figures 2 and 3. Overall, the included studies were of good quality.

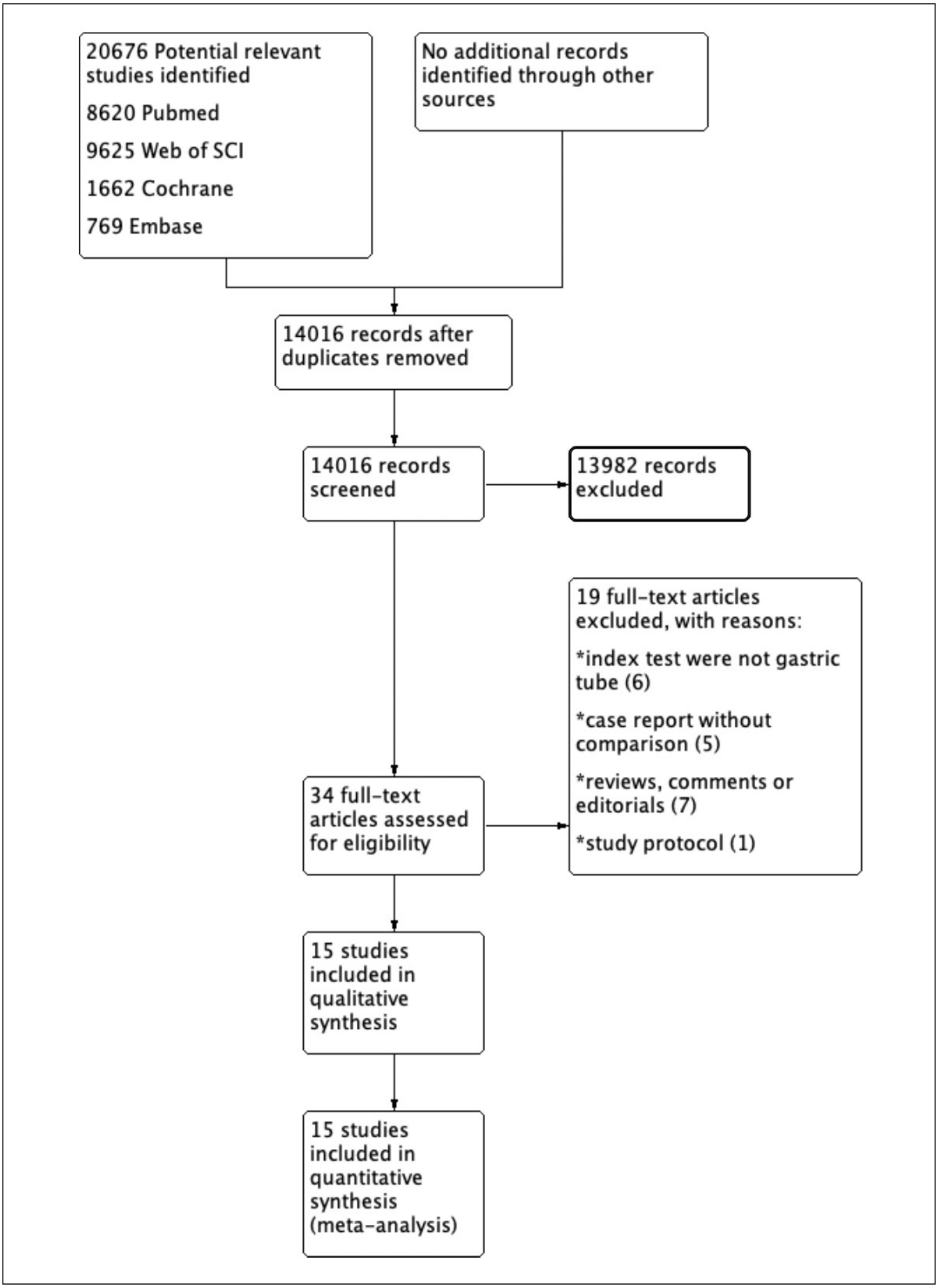

Figure 1. Study flow diagram.

Table I. Summary of the pooled test characteristics.

Study ID	TP	FP	FN	TN	Participants	Setting	Operator	Study sample	Method	Echo window	Reference standard
Vigeau et al[26]	34	0	1	0	35	ICU	Physicians	Over 18 years of age	Ultrasound + air injection after insertion	Epigastric	X-ray
Brun et al[18]	80	0	8	8	96	Prehospital	Physicians	Over 18 years of age	Ultrasound after insertion	Epigastric	X-ray
Chenaitia et al[8]	116	0	2	12	130	Prehospital	Physicians	Over 18 years of age	Ultrasound after insertion	Epigastric	X-ray
Kim et al[22]	38	1	6	2	47	Emergency	Physicians	Over 18 years of age	Ultrasound +saline and air injection	Neck + epigastric	X-ray
Brun et al[9]	27	0	1	4	32	Prehospital	Physicians	Over 18 years of age	Ultrasound +air injection after insertion	Neck + epigastric	X-ray
Gok et al[21]	52	0	4	0	56	ICU	Physician	Over 18 years of age	Ultrasound during insertion	Neck	X-ray
Yildirim et al[27]	45	0	2	2	49	Emergency	Physician	Over 18 years of age	Ultrasound +air and liquid injection after insertion	Neck + epigastric	X-ray
McMullen et al[10]	22	0	3	0	25	ICU	Physician	Over 18 years of age	Ultrasound after insertion	Neck + epigastric	X-ray
Dias et al[20]	154	2	3	0	159	Neonatal intensive care unit	Physician	Newborns	Ultrasound after insertion	Epigastric + Gastric	X-ray
Munoli et al[24]	408	7	30	81	526	Internal Medicine and ICU	Physician	Over 18 years of age	Ultrasound +air injection after insertion	Epigastric	X-ray
Claiborne et al[19]	23	0	3	0	26	pediatric emergency	Physician	Pediatric	Ultrasound after insertion	Gastric + epigastric	X-ray
Tai et al[29]	66	0	3	3	72	emergency	Nurse	Over 18 years of age	Ultrasound after insertion	Neck	X-ray
Tsolaki et al[25]	372	1	4	0	377	ICU	Physician	Over 18 years of age	Ultrasound +air injection after insertion	Epigastric	X-ray
Zatelli et [al]28	114	0	0	0	114	ICU	Physician	Age range of 14–89	Ultrasound +air injection after insertion	Neck + epigastric	X-ray
Mak et al[23]	63	0	3	2	68	Community	Nurse	Over 18 years of age	Ultrasound +air injection after insertion	Neck + epigastric	X-ray

TP: true positive; incorrect gastric tube placement and correct visualization by ultrasound.
FP: false positive; incorrect gastric tube placement but not visualized by ultrasound.
FN: false negative; correct gastric tube placement but not visualized by ultrasound.
TN: true negative; incorrect gastric tube placement and correct visualization by ultrasound.
NR: not reported.
Inconclusive as negative

Results

Characteristics of Participants and the Index Test

Overall, 1,812 participants were included in this review. The number of appropriate tube placements was 1,687 (93.1%) insertions, and the number of misplacements was 125 (6.9%). Two of the included studies assessed the diagnostic accuracy of ultrasonography for gastric tube placement confirmation in pediatric and newborn patients. Three studies were conducted in a prehospital setting. Four studies were conducted in the emergency department. Seven studies were conducted in the intensive care unit. One study was conducted in a community. We found three ultrasound methods of confirming the presence of gastric tubes. Seven studies reported the diagnostic accuracy of ultrasonography alone, whereas others reported the diagnostic accuracy of ultrasonography combined with liquid and/or air injection. Four ultrasound echo windows were used: neck approach, epigastric approach, combination of neck and epigastric, and a combination of epigastric and gastric. None of the studies reported any complications related to ultrasound testing. Two studies reported that ultrasonography was performed by trained nurses. In other studies, ultrasonography was performed by physicians. A summary of the included studies is shown in Table I. The performer's interpretation of the results was also considered. All included studies used X-ray images as the reference standard. No misinterpretation of X-ray images in the gastric tube position has been reported (as shown by other reliable clinical tests).

Diagnostic Accuracy Estimates of the Included Studies

As shown in Figure 4, forest plots were used to display the number of TP, TN, FP, and FN, as well as sensitivity and specificity, with 95% CI for all the included studies.

Five studies were not included in the calculation of the pooled sensitivity and specificity because specificity data were not available. We performed a meta-analysis to determine the pooled ultrasound diagnostic accuracy estimates for the nine studies. The sensitivities and specificities of the other nine studies are shown in Figures 5 and 6, respectively. The SROC curves, together with the summary point 95% CIs and prediction regions, are illustrated in Figure 7. The results included a pooled sensitivity of 0.96 (95% CI 0.94-0.97), specificity of 0.91 (95% CI 0.85-0.96), positive likelihood ratio (PLR) of 5.08 (95% CI 1.49-17.39), and negative likelihood ratio (NLR) of 0.08 (95% CI 0.06-0.10).

The summary sensitivity and specificity values were high, but heterogeneity between studies was moderate and could be assessed visually using forest plots (Figure 5) and prediction ellipses (Figure 6). The summary sensitivity and specificity values were high, but heterogeneity between studies was moderate and could be assessed visually using forest plots (Figures 5 and 6) and prediction ellipses (Figure 7).

We explored the factors that influence the diagnostic accuracy of ultrasonography, including different settings and ultrasound performers. The results included the pooled sensitivity, specificity, PLR, NLR, SROC, and diagnostic OR (Table II).

Summary of Results

This review evaluated the diagnostic accuracy of ultrasonography for the confirmation of gastric tube placement. Most results showed high point estimates for correct tube detection (sensitivity). Among studies assessing the diagnostic accuracy of ultrasound alone, we found three different visualization methods: the neck approach, epigastric approach, and a combination of these approaches. The ultrasonography summary sensitivity of 0.96 (95% CI 0.94-0.97) suggests that ultrasonography yields good diagnostic performance in predicting correct gastric tube placement.

The summary specificity of ultrasonography was 0.91 (95% CI 0.85-0.96), with an extremely high specificity value. However, this study included only a small number of participants to determine tube misplacement (specificity). In addition, data on the accuracy of tube placement in children are limited.

We planned to explore the factors that affect the diagnostic accuracy of ultrasonography, including whether the test was performed before the index test; whether the test involved injection of a small amount of saline or air into the gastric tube; different visualization areas used (stomach alone or stomach, neck, and esophageal areas); and size of the NGT. However, we were unable to explore these factors because the required information was unavailable or limited.

Strengths and Weaknesses of the Review

The main limitation of this review was the relatively moderate heterogeneity of the included

Figure 2. Risk of bias and applicability concerns summary: review authors' judgments about each domain for each included study.

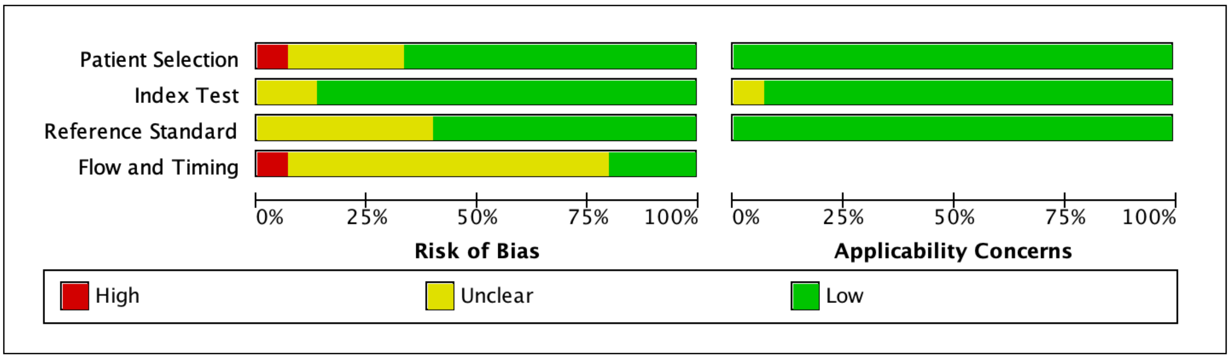

Figure 3. Graph of risk of bias and applicability concerns: review authors' judgments about each domain presented as percentages across included studies.

Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Brun et al[18]	80	0	8	8	0.91 [0.83, 0.96]	1.00 [0.63, 1.00]
Brun et al[9]	27	0	1	4	0.96 [0.82, 1.00]	1.00 [0.40, 1.00]
Chenaitia et al[8]	116	0	2	12	0.98 [0.94, 1.00]	1.00 [0.74, 1.00]
Claiborne et al[19]	23	0	3	0	0.88 [0.70, 0.98]	Not estimable
Dias et al[20]	154	2	3	0	0.98 [0.95, 1.00]	0.00 [0.00, 0.84]
Gok et al[21]	52	0	4	0	0.93 [0.83, 0.98]	Not estimable
Kim et al[22]	38	1	6	2	0.86 [0.73, 0.95]	0.67 [0.09, 0.99]
Mak et al[23]	63	0	3	2	0.95 [0.87, 0.99]	1.00 [0.16, 1.00]
McMullen et al[10]	22	0	3	0	0.88 [0.69, 0.97]	Not estimable
Munoli et al[24]	408	7	30	81	0.93 [0.90, 0.95]	0.92 [0.84, 0.97]
Tai et al[29]	66	0	3	3	0.96 [0.88, 0.99]	1.00 [0.29, 1.00]
Tsolaki et al[25]	372	1	4	0	0.99 [0.97, 1.00]	0.00 [0.00, 0.97]
Vigeau et al[26]	34	0	1	0	0.97 [0.85, 1.00]	Not estimable
Yildirim et al[27]	45	0	2	2	0.96 [0.85, 0.99]	1.00 [0.16, 1.00]
Zatelli et al[28]	114	0	0	0	1.00 [0.97, 1.00]	Not estimable

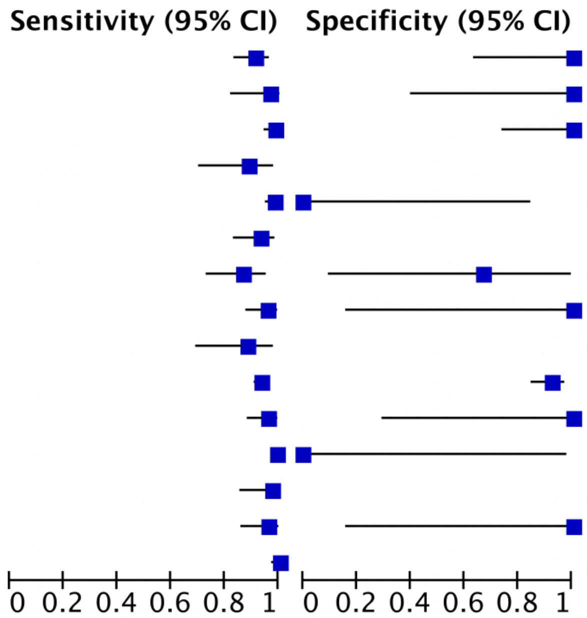

Figure 4. Forest plot of the diagnostic accuracy of ultrasonography in different ways.

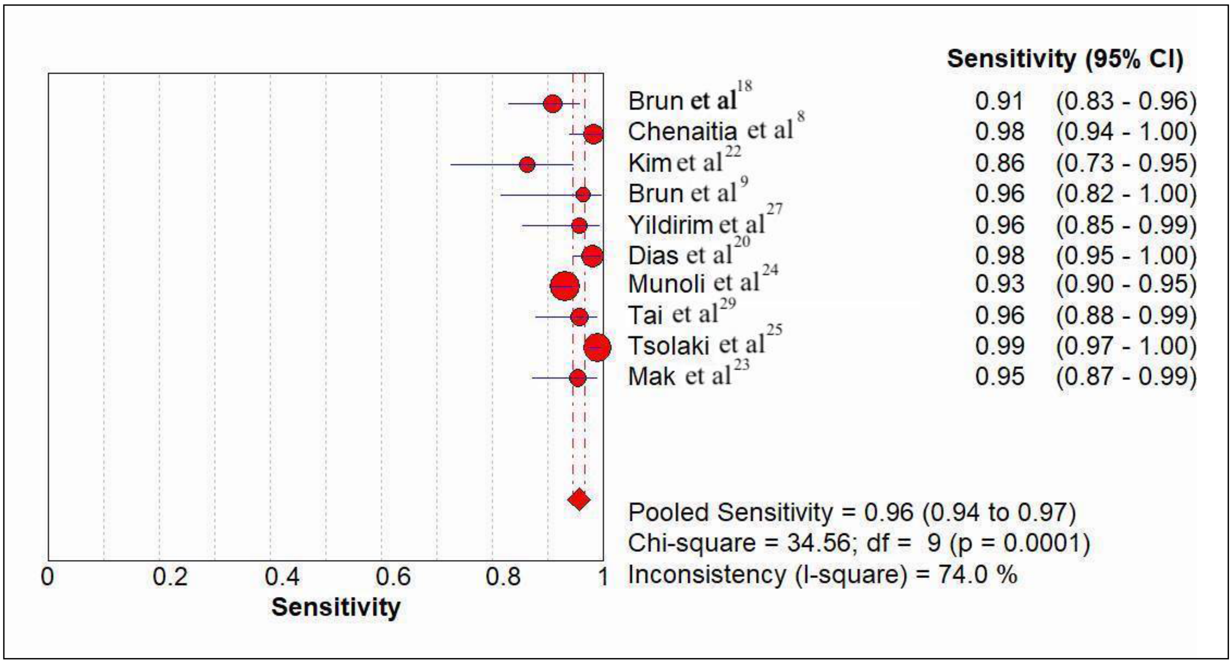

Figure 5. Forest plots of the sensitivity of ultrasonography for gastric tube placement. TP, true positive; FP, false positive; FN, false negative; TN, true negative. Values between brackets are the 95% CIs of sensitivity and specificity. The figure shows the estimated sensitivity of the study and its 95% CI.

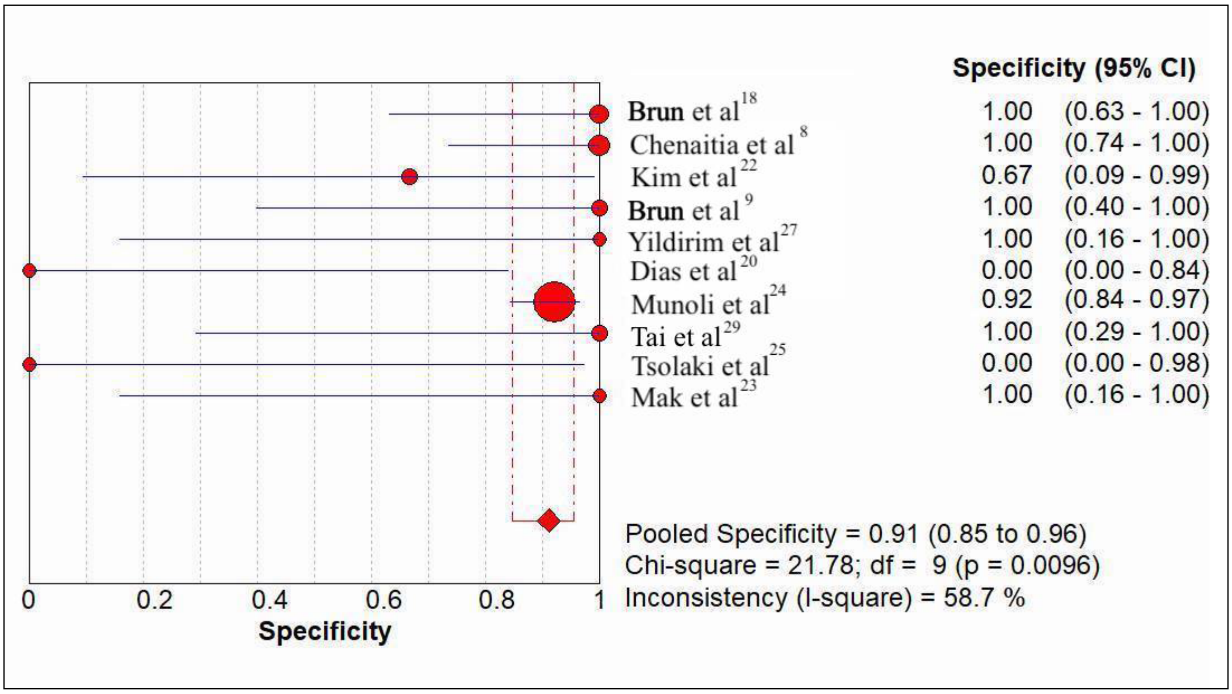

Figure 6. Forest plots of the specificity of ultrasonography for gastric tube placement. The figure shows the estimated specificity of the study and its 95% CI.

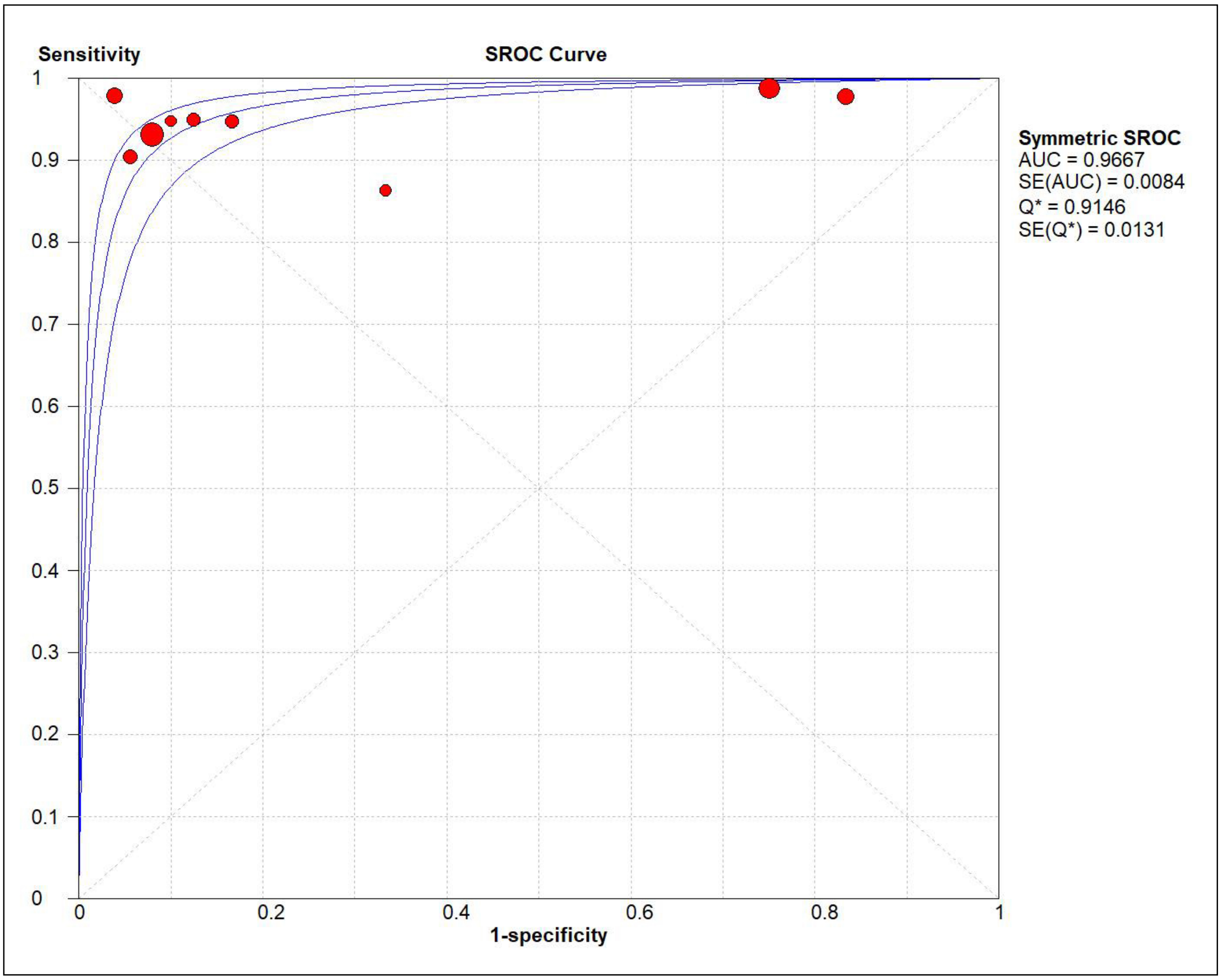

Figure 7. Summary plots of nine studies investigating the diagnostic ability of ultrasonography to detect gastric tube position.

studies, which may partially undermine the reliability and reproducibility of the results. Moreover, literature data do not allow the identification of possible sources of heterogeneity. Meanwhile, the review included only English-language publications and, therefore, may not be representative of worldwide studies.

Conclusions

Our findings support the use of ultrasonography to confirm gastric tube placement. The diagnostic performance of ultrasound can be considered clinically useful for confirming correct NGT placement, although insufficient

Table II. Summary of the pooled test characteristics.

Variables	Sensitivity (95%CI)	Specificity (95%CI)	LR+	LR-	AUROC (95%CI)	Diagnostic OR	I^2 (95%CI)
Ultrasonography	0.96 (0.94-0.97)	0.91 (0.85-0.96)	5.08 (1.49-17.39)	0.08 (0.06-0.10)	0.966	114.76(59.37-221.83)	0.00%
Physician-performed	0.96 (0.94-0.97)	0.91 (0.84-0.95)	4.88 (1.19-19.98)	0.08 (0.05-0.11)	0.975	93.83 (35.51 -247.94)	21.3%
Nurse-performed	0.96 (0.91-0.98)	1.00 (0.48-1.00)	6.55 (1.07-40.08)	0.06 (0.03-0.13)	NR	110.30 (11.59-1049.62)	0.00%
ICU setting	0.96 (0.95-0.97)	0.89 (0.81-0.95)	2.62 (0.27-25.73)	0.07 (0.05-0.11)	0.975	58.35 (9.25-368.20)	46.8%
Prehospital setting	0.95 (0.92-0.98)	1.00 (0.86-1.00)	15.61 (3.32-73.36)	0.05 (0.02-0.16)	0.983	316.57 (52.45-1910.88)	0.00%
Emergency setting	0.93 (0.88-0.97)	0.88 (0.47-1.00)	3.90 (1.17-12.95)	0.09 (0.04-0.21)	0.986	42.37 (7.75-231.56)	0.00%

evidence suggests that ultrasonography can be used as a diagnostic tool for incorrect gastric tube placement.

Conflict of Interests

The authors declare that they have no competing interests.

Declaration of Funding Interests

None.

Ethical Approval

The study did not involve human participants and ethics approval is not applicable.

References

1) McLaren S, Arbuckle C. Providing optimal nursing care for patients undergoing enteral feeding. Nurs Stand 2020; 35: 60-65.
2) Compher C, Bingham AL, McCall M. Guidelines for the provision of nutrition support therapy in the adult critically ill patient: The American Society for Parenteral and Enteral Nutrition. JPEN J Parenter Enteral Nutr 2022; 46: 12-41.
3) Ferrer-Inaebnit E, Bonnin-Pascual J, Pineño-Flores C, González-Argente X. Oropharyngeal perforation secondary to nasogastric tube placement. Cir Esp (Engl Ed) 2021; 99: 612.
4) Leow TH, Lam S, Kumar B. Rare and dangerous complication of nasogastric tube insertion. BMJ Case Rep 2020; 13: e235677.
5) Fletcher J. Nutrition: safe practice in adult enteral tube feeding. Br J Nurs 2011; 20: 6-9.
6) Bourgault AM, Heath J, Hooper V, Sole ML, Waller JL, Nesmith EG. Factors influencing critical care nurses' adoption of the AACN practice alert on verification of feeding tube placement. Am J Crit Care 2014; 23: 134-144.
7) Sorokin R, Gottlieb JE. Enhancing patient safety during feeding-tube insertion: a review of more than 2,000 insertions. JPEN J Parenter Enteral Nutr 2006; 30: 440-445.
8) Chenaitia H, Brun PM, Querellou E. Ultrasound to confirm gastric tube placement in prehospital management. Resuscitation 2012; 83: 447-451.
9) Brun PM, Chenaitia H, Lablanche C. 2-point ultrasonography to confirm correct position of the gastric tube in prehospital setting. Mil Med 2014; 179: 959-963.
10) McMullen CD, Anstey C, Garrett P, Moore J. Nasogastric tube placement under sonographic observation: A comparison study of ultrasound and chest radiography in mechanically ventilated patients. Aust Crit Care 2022; 35: 181-185.
11) Heidarzadi E, Jalali R, Hemmatpoor B, Salari N. The comparison of capnography and epigastric auscultation to assess the accuracy of nasogastric tube placement in intensive care unit patients. BMC Gastroenterol 2020; 20: 196.
12) Tsujimoto H, Tsujimoto Y, Nakata Y, Akazawa M, Kataoka Y. Ultrasonography for confirmation of gastric tube placement. Cochrane Database Syst Rev 2017; 4: Cd012083.
13) McInnes MDF, Moher D, Thombs BD. Preferred Reporting Items for a Systematic Review and Meta-analysis of Diagnostic Test Accuracy Studies: The PRISMA-DTA Statement. JAMA 2018; 319: 388-396.
14) Whiting PF, Rutjes AW, Westwood ME. QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies. Ann Intern Med 2011; 155: 529-536.
15) Reitsma JB, Glas AS, Rutjes AW, Scholten RJ, Bossuyt PM, Zwinderman AH. Bivariate analysis of sensitivity and specificity produces informative summary measures in diagnostic reviews. J Clin Epidemiol 2005; 58: 982-990.
16) Deeks JJ, Altman DG. Diagnostic tests 4: likelihood ratios. BMJ 2004; 329: 168-169.
17) Zamora J, Abraira V, Muriel A, Khan K, Coomarasamy A. Meta-DiSc: a software for meta-analysis of test accuracy data. BMC Med Res Methodol 2006; 6: 31.
18) Brun PM, Chenaitia H, Bessereau J. [Ultrasound evaluation of the nasogastric tube position in prehospital]. Ann Fr Anesth Reanim 2012; 31: 416-420.
19) Claiborne MK, Gross T, McGreevy J, Riemann M, Temkit M, Augenstein J. Point-of-Care Ultrasound for Confirmation of Nasogastric and Orogastric Tube Placement in Pediatric Patients. Pediatr Emerg Care 2021; 37: e1611-e1615.
20) Dias FSB, Alvares BR, Jales RM. The Use of Ultrasonography for Verifying Gastric Tube Placement in Newborns. Adv Neonatal Care 2019; 19: 219-225.
21) Gok F, Kilicaslan A, Yosunkaya A. Ultrasound-guided nasogastric feeding tube placement in critical care patients. Nutr Clin Pract 2015; 30: 257-260.
22) Kim HM, So BH, Jeong WJ, Choi SM, Park KN. The effectiveness of ultrasonography in verifying the placement of a nasogastric tube in patients with low consciousness at an emergency center. Scand J Trauma Resusc Emerg Med 2012; 20: 38.
23) Mak MY, Tam G. Ultrasonography for nasogastric tube placement verification: an additional reference. Br J Community Nurs 2020; 25: 328-334.
24) Mumoli N, Vitale J, Pagnamenta A, et al. Bedside Abdominal Ultrasound in Evaluating Nasogastric Tube Placement: A Multicenter, Prospective, Cohort Study. Chest 2021; 159: 2366-2372.
25) Tsolaki V, Zakynthinos GE, Zygoulis P, Bardaka F, Malita A, Aslanidis V, Zakynthinos E, Makris D. Ultrasonographic Confirmation of Nasogastric Tube Placement in the COVID-19 Era. J Pers Med 2022; 12: 337.
26) Vigneau C, Baudel JL, Guidet B, Offenstadt G, Maury E. Sonography as an alternative to radiography for nasogastric feeding tube location. Intensive Care Med 2005; 31: 1570-1572.

27) Yıldırım Ç, Coşkun S, Gökhan Ş, Pamukçu Günaydın G, Özhasenekler A, Özkula U. Verifying the Placement of Nasogastric Tubes at an Emergency Center: Comparison of Ultrasound with Chest Radiograph. Emerg Med Int 2018; 2018: 2370426.

28) Zatelli M, Vezzali N. 4-Point ultrasonography to confirm the correct position of the nasogastric tube in 114 critically ill patients. J Ultrasound 2017; 20: 53-58.

29) Tai PH, Lau WS, Chan PY, Ng SY, Mak YT. Nurse Performed Ultrasonography in Confirming the Position of Nasogastric Tube in the Emergency Department: A Prospective Single Group Diagnostic Test Study. Hong Kong Journal of Emergency Medicine 2016; 23: 340-349.